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(54) Abstract Title
Capacitive sensing of contents of envelopes

(57) The contents of sealed envelopes are accessed by detecting and digitizing a change in capacitance produced when a pattern of dielectric or conductive ink is passed by a sensitive capacitance sensor 13. The capacitance changes are converted into corresponding electrical patterns for further processing.

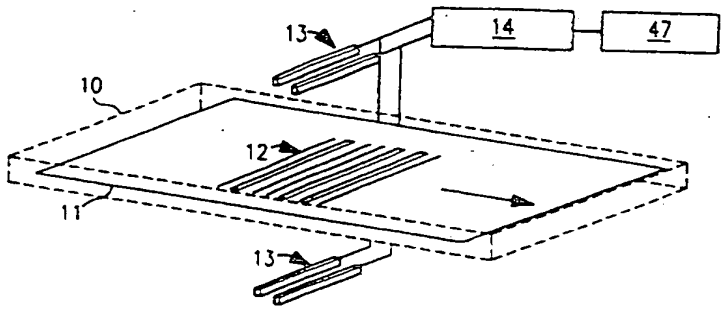

FIG. 1

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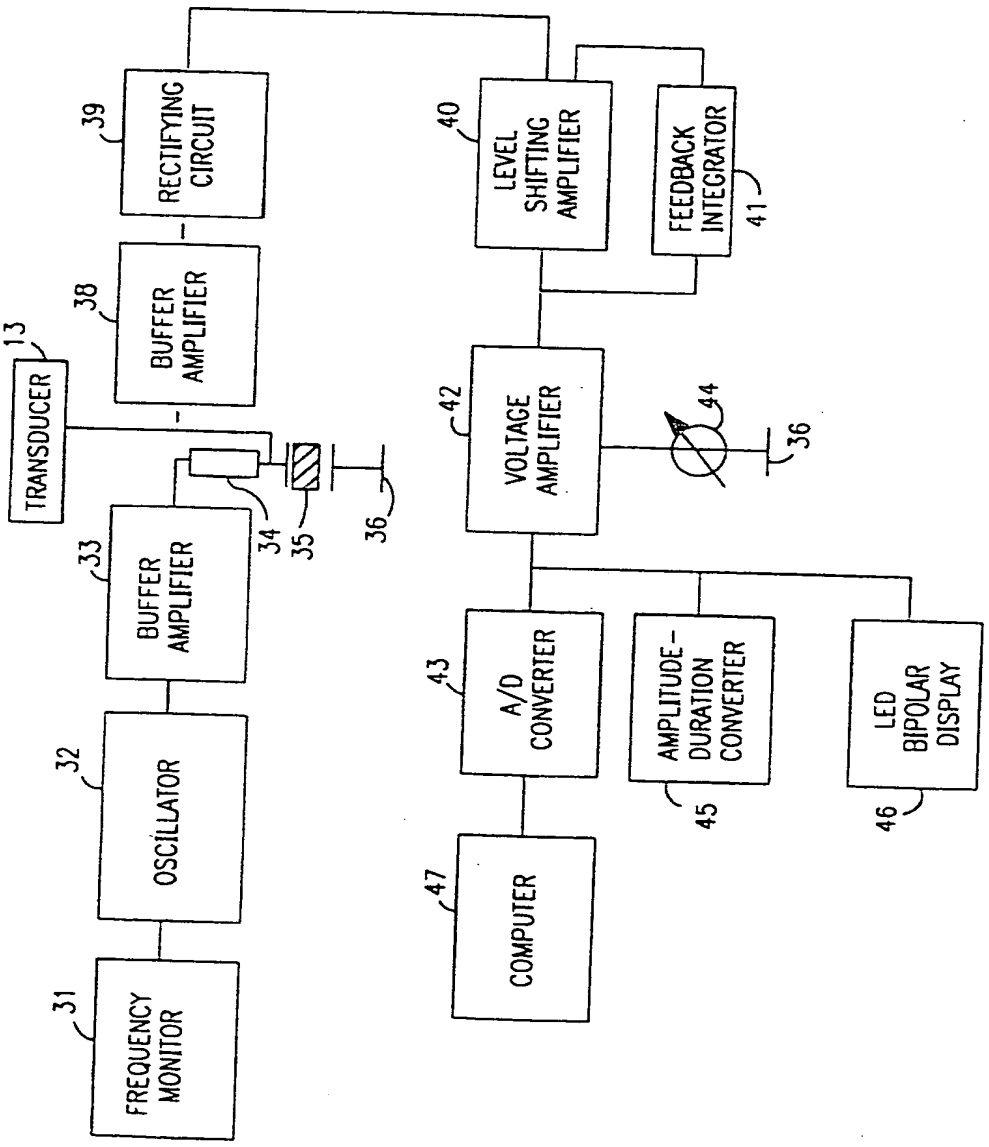
FREQUENCY MONITOR
31
OSCILLATOR
32
BUFFER AMPLIFIER
33
TRANSDUCER
13
BUFFER AMPLIFIER
38
RECTIFYING CIRCUIT
39
34
35
36
LEVEL SHIFTING AMPLIFIER
40
FEEDBACK INTEGRATOR
41
VOLTAGE AMPLIFIER
42
44
36
A/D CONVERTER
43
AMPLITUDE-DURATION CONVERTER
45
LED BIPOLAR DISPLAY
46
COMPUTER
47

FIG. 3

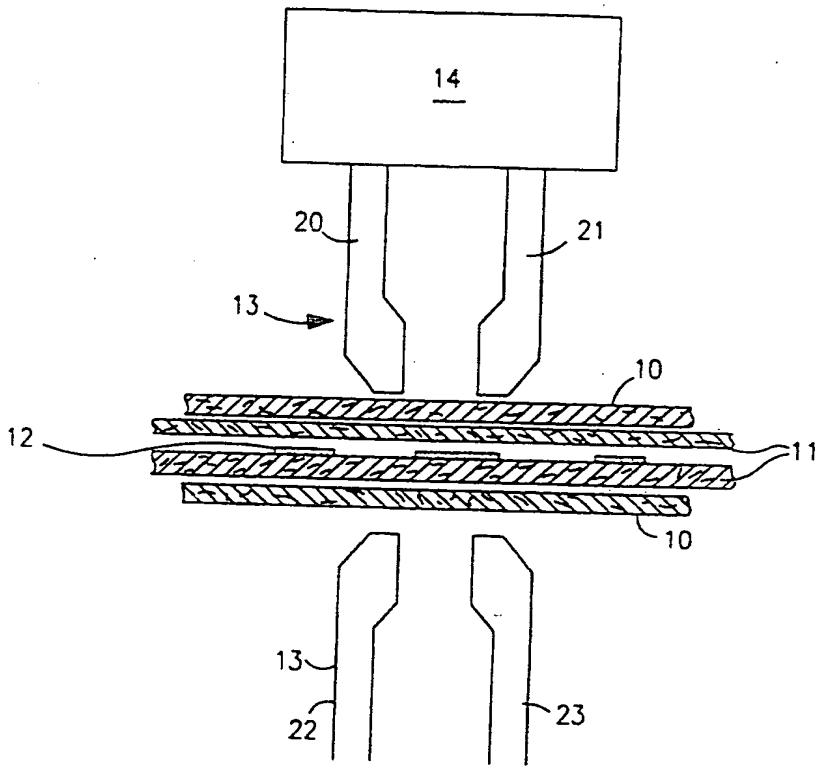

FIG. 5

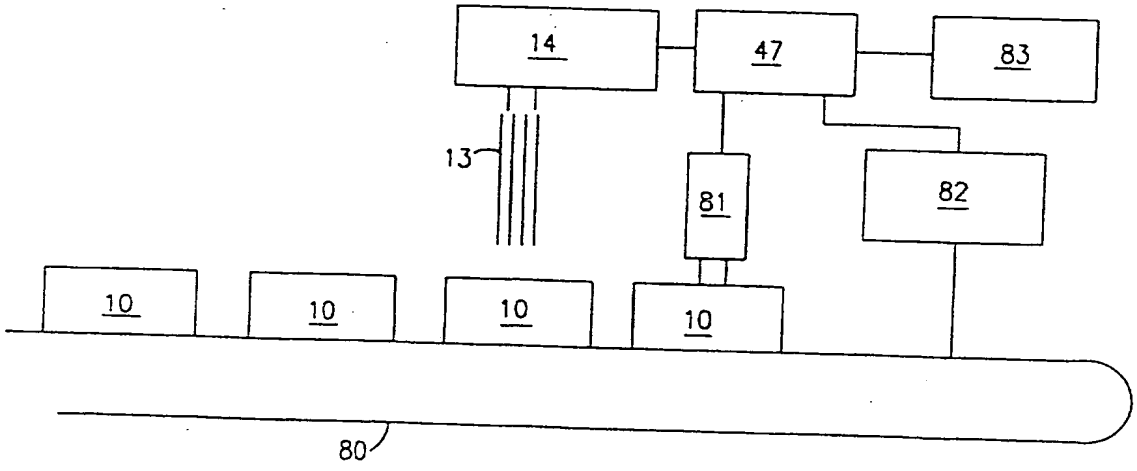

FIG. 6

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CAPACITIVE METHOD AND APPARATUS FOR ACCESSING CONTENTS OF ENVELOPES AND OTHER SIMILARLY CONCEALED INFORMATION

The invention relates to the acquisition of encoded information from the contents of sealed envelopes or other layered structures that conceal the information from view.

Much of bulk return mail is processed with at least some manual handling, especially when it contains orders. Once cut open, the envelopes are generally emptied by hand; and information from their contents is keyboarded, optically scanned, or otherwise entered into a computer. The required steps of opening the envelopes, separating their contents, and entering relevant data are expensive and time consuming. Also, data entry is subject to error, especially when information from the separated envelopes must be linked to information from their contents.

Outgoing mail, which may be passed through inserters, is also subject to sorting and other processing errors that are difficult to detect; because once sealed, the contents are concealed from view. Various attempts have been made to "see through" the envelopes to read their contents without opening them, but problems plague each.

U.S. Patent 5,522,921 to Custer proposes use of x-rays for reading envelope contents that are printed with special x-ray opaque materials. The x-rays are intended to penetrate the envelopes and their contents except where blocked by the special materials. A resulting shadow pattern is detected by an x-ray reading device.

the surface of an envelope. Instead, a transducer measures changes in capacitance of a localized region beneath the surface of the envelope, such as can be produced by conductive inks or inks with a dielectric constant different from the paper upon which it is printed. This technique shares common elements with other inventions, particularly those for authenticating lottery tickets, documents, and currency, yet is substantially different in both function and purpose.

U.S. Patent 5,621,200 to Irwin, Jr. et al. discloses an electronic validation system for scratch-off lottery tickets. A conductive ink containing a pattern of resistors is printed as a portion of the scratch-off material or underlying play indicia. Capacitors are used to couple the printed resistor circuits to an electronic verification machine to verify electronic signature patterns of the resistor circuits. The electronic signatures are comparable to predetermined standards, but they do not contain information encoded in conventional formats that can be read as alphanumeric characters. Also, each ticket must be tested one at a time at a predetermined position within the verification machine.

U.S. Patent 3,519,802 to Cinque et al. discloses an early attempt at authenticating credit cards with internally encoded data. Conductive plates are arranged in a pattern; and their presence, absence, or proximate orientation is detected by a capacitance sensor. However, the detection system requires the conductive plates to be bent into two offset planes that complicate manufacture and are not readily applicable to thinner substrates such as sheet materials normally enclosed by envelopes.

U.S. Patent 4,591,189 to Holmen et al. discloses a more recent example of a credit card verification system in which a light transmitting authenticating layer is sandwiched between two anti-reflective film layers. The authenticating layer is preferably vacuum deposited, such as by sputtering, but can also be formed by a printed layer of conductive ink. The impedance, conductance, or capacitance of the authenticating layer can be detected, though capacitance is not recommended for detecting discrete areas of the

For example, the processing information can be arranged to identify intended addressees of the envelopes. The actual addressees can be read by standard optical means from the exterior of the envelopes and compared to the address information obtained from their contents to verify if they match. The further processing of the envelopes is discontinued upon detection of a mismatch. Alternatively, the address information obtained from the envelopes' contents can be used to print corresponding address information on the exterior of the envelopes. Orders for further processing can also be read from the envelopes' contents.

A system for carrying out the invention can include a transporter that conveys a succession of covered substrates imprinted with conductive ink in patterns representing encoded information visibly obscured by a cover. A capacitance measuring device through which the succession of covered substrates are transported is sensitive to variations in capacitance associated with the patterns of the conductive ink as a function of the transported positions of the covered substrates through the capacitance measuring device. A processor matches the measured variations in capacitance to stored information about similar patterns for reading the encoded information, and a sorter distinguishes subsequent processing of the covered substrates based on the encoded information imprinted on the substrates and obscured by the cover.

The capacitance variations are preferably sensed by a transducer comprising (a) parallel plates of a capacitor placed side-by-side on one side of the covered substrates, (b) one pair of such side-by-side plates on each side of the covered substrates, (c) a pair of such plates on one side of the covered substrates and a ground plane on the other side of the covered substrates, or (d) a pair of plates aligned end-to-end on one side of the covered substrates. An output signal is detected by means of a circuit that converts what amounts to an impedance change into a voltage change which can then be used to drive an A/D converter with its output fed to a computer where the signal can be processed to retrieve information and control other processes.

(also referred to as a transducer) 13 which are connected to an amplifier 14 whose output is then examined by a computer 47. The bar-code 12 is printed using either a conductive ink or a dielectric ink. When either passes between the plates 13 of the transducer, the capacitance changes.

In a practical embodiment of the invention, the envelope is passed between two parallel sets of plates as shown in Figure 2. When no envelope is present between plates 20 - 21 and 22 - 23 of the transducer 13, the capacitance is C_0 and this is made part of a resonant circuit built into the amplifier 14, whose frequency is established by a suitable choice of inductance L. When an envelope 10 passes the probe (transducer 13), the capacitance changes to C_1. A further change to C_2 is sensed when the conductive or dielectric ink, with a permittivity other than that of the insert 11 within the envelope 10, passes between the plates 20 - 21 and 22 - 23.

The inserts 11 on which encoded information is printed are preferably paper, which is a dielectric. However, other non-conducting materials including resin films or fabric materials can also be used as substrates for supporting conductive substances or substances with different permittivities. The conductive ink used for printing the bar-code 12 can be visible for conveying additional optically readable information on the inserts 11 or can be invisible for performing other functions such as those relating to tracking, accounting, or security. The bar-code 12 can also be hidden between layers of the inserts 11 for similar purposes. An example of a conductive ink appropriate for these purposes is used in a Hewlett-Packard desk jet printer, model number 870CSE.

In the block diagram of Figure 3, an oscillator circuit 32 is used to generate a fixed frequency based on a Colpitts-crystal modified circuit. A frequency monitor 31 allows the operation of the instrument to be monitored for test purposes while also improving the frequency stability.

The output of the oscillator 32 is fed through a buffer amplifier 33, which is also part of the oscillator circuit 32. The buffer amplifier 33 is a voltage source which together with an

Further undesirable signals that may pass through what is essentially a high-pass filter (integrator 41) can be discriminated against by initially adjusting a threshold level of the amplifier 42 using a voltage source 44.

A second input to the A/D converter 43 is produced by an amplitude-duration converter 45, which offers a pulse train representation of the signals introduced at the transducer 13. These signals will have an amplitude that is a function of the width of the lines of the bar-code 12, for example. The lines of the bar-code 12 have a variety of widths; and the change in impedance sensed by the transducer 13 depends on this width, which is equivalent to changing the plate area of the effective capacitor created by the conductive or dielectric lines of the bar-code 12 as they pass by the transducer 13.

A LED bipolar display 46 is used in conjunction with the threshold level adjustment control of voltage source 44 to set initial conditions for the amplifier 42. The display 46 indicates a range of voltages from negative to positive values with respect to a zero-centered reference representing the floating ground 36.

The output of the A/D converter 43 is sent to a computer 47, which allows the signals produced at the transducer 13 to be decoded. This information from the computer 47 can also be used to control the speed at which envelopes are sent past the transducer 13, and the same information can be used to drive a feedback loop to drive the voltage source 44 to remove undesirable signals such as can be produced by accumulated static charges.

In Figure 4, a circuit 50 acts as a buffer to the frequency monitor 31, which also forms part of the oscillator circuit 32 with a capacitance 60 introduced into the emitter of a main oscillator transistor 61. High stability (10^{-7}) in frequency is obtained in the oscillator circuit 32 by using a crystal 62 (f_{31}=4.93152 MHz) in combination with a phase shifter 63. The combined effect of capacitance 60 and those of the base-collector of the transistor 61 and an element 64 will increase the capacitance of an element 65 by an amount sufficient to sustain an oscillation. In this way, buffer

of the divider circuit consisting of the impedance 34 and the crystal 35. The decreased resulting signal will be amplified by the bootstrapped buffer amplifier 38 and supplied to the rectifying circuit 39.

Note that the signal collected from the transducer 13 (the same as the signal collected across crystal 35) will sharply decrease for very small capacitive changes of 10^{-2} to 10^{-3} pF (values corresponding to those expected for coded information printed with conductive inks as independently determined using a professional LCR reference meter) because of the high Q of the resonator crystal 35 and the high impedances and low capacitances on either side of the crystal 35.

Following the rectifying circuit 39, the signal is processed by the level-shifting amplifier 40 and the feedback integrator 41. The signal at the emitter of a transistor 67 is above the floating ground in a positive voltage domain, creating an undesirable "common mode" for an amplifier 69. A feedback loop is therefore included which consists of an integrator 70 and a transistor 75, which will adjust the inverting input voltage of the amplifier 69 to be the same as the level of the non-inverting input of the same amplifier.

The output signal of the amplifier 69 will be forced in this way to the level of the floating ground 36 taking into account that the integrator 70 is self-creating a zero voltage between its inputs. The integrator 70 time-constant, which is determined by the product of elements 71 and 72, is much larger than the expected pulse duration of the signal produced at the transducer 13 but shorter than the time scale of expected temperature variations that can affect the signal. Previous art (U.S. Patent 5,231,359) has used a similar technique to modify the reactance of the resonator crystal 35 by altering a variable capacitance diode in parallel with the resonator. This requires many additional electronic circuit elements and does not negate the temperature effects suffered by the integrator 70 itself on the resonator side upon which it acts. In our circuit, all summed temperature effects are canceled at the level shifter, thus not affecting the performance of the resonator. Another advantage

23 will be modified by the presence of conductive or dielectric ink of the bar-code 12 on the insert(s) 11 enclosed in the envelope 10. By arranging an array of such transducers 13 to cover the width of an envelope passing the array, an image of the contents of the envelope can be built up within the computer 47, making use of the translation of the envelope past the transducers as the time base.

Figure 6 shows a train of envelopes 10 being driven past the transducer 13 by means of a conventional envelope transport mechanism such a belt drive 80. The signals amplified by amplifier 14 are fed into the computer 47 and interpreted to suit the needs of a particular use. For example, conventional recognition programs can be run to interpret the information pattern of the bar-code 12. The computer 47 can also be used to monitor the speed with which the envelopes 10 are measured to arrive at the transducer 13, and this information can be used to alter the speed of a drive 82 for the transport belt 80.

A variety of further processing can take place based on the information acquired from contents 83 of the envelopes 10. For example, the envelopes 10 can be sorted according to their contents 83, orders or replies can be generated, records can be updated, or the information can be verified. In the in-line system of Figure 6, a conventional printer 81 is controlled to print information on the envelopes' outer surfaces (exteriors), which is linked to the information acquired from the contents 83 of the envelopes 10. For example, addresses can be printed to match address or other identifying information acquired from the contents 83 of the envelopes 10.

Instead of printing the address information on the envelopes' outer surfaces, previously printed address information could be read from the envelopes' outer surfaces by a conventional optical reader and compared with the identifying information acquired from their contents. Further processing of the envelopes can be interrupted upon detection of a mismatch between the two addresses, and the mismatch can be corrected.

CLAIMS

1. A method of reading information encoded on a substrate and visibly concealed behind a cover comprising the steps of:

printing the encoded information on the substrate in a pattern using an electrically conductive ink;

moving the encoded substrate and cover past a capacitance sensor at a rate that permits successive portions of the pattern to be measured at points of approximately equal proximity to the capacitance sensor;

detecting variations in capacitance associated with the pattern of the conductive ink as a function of a relative position of the capacitance sensor along the covered substrate; and

matching the detected variations in capacitance to stored information about similar patterns for reading the encoded information.

2. The method of claim 1 in which the encoded information is printed in the form of a bar code.

3. The method of claim 1 in which the encoded information is printed on the substrate in patterns that represent alphanumeric characters.

with patterns of the processing information recorded as a contrast in permittivity between the patterns and an underlying substrate;

deciphering the patterns into recognized units of information; and

distinguishing subsequent processing among envelopes on the basis of the processing information obtained from their contents.

10. The method of claim 9 in which said step of distinguishing includes sorting the envelopes in accordance with the processing information obtained from their contents.

11. The method of claim 9 or claim 10 in which said processing information identifies intended addressees of the envelopes.

12. The method of claim 11 comprising the further steps of reading address information printed on an exterior of the envelopes and comparing the address information from the envelopes with the intended addressees obtained from their contents to determine if they match.

13. The method of claim 12 in which said step of distinguishing includes interrupting further processing

19. The method of any one of claims 9 to 18 in which said step of deciphering includes converting the patterns of processing information into equivalent alphanumeric characters.

20. A system for assessing and processing hidden information imprinted on a succession of covered substrates comprising:

a transporter for conveying a succession of covered substrates imprinted with conductive ink in patterns representing encoded information visibly obscured by a cover;

a capacitance measuring device through which said succession of covered substrates are transportable, the capacitance measuring device being sensitive to variations in capacitance associated with the patterns of the conductive ink as a function of a transported position of the covered substrates through the capacitance measuring device;

a processor that matches the measured variations in capacitance to stored information about similar patterns for reading the encoded information; and

a sorter for distinguishing subsequent processing of the covered substrates based on the encoded information imprinted on the substrates and obscured by the cover.

of plates located adjacent to one side of the covered substrates.

27. The system of claim 26 in which said plates are arranged in parallel and oriented normal to a direction at which the covered substrates are transported past said plates.

28. The system of claim 26 in which said plates are aligned end-to-end and oriented normal to a direction at which the covered substrates are transported past said plates.

29. The system of any one of claims 26 to 28 in which said encoded information is printed in the form of a bar code, and said plates are aligned with the bar code.

30. The system of any one of claims 26 to 29 in which capacitance is detected through an impedance change produced in a sensing circuit of the capacitance measuring device.

31. The system of any one of claims 20 to 28 in which the conductive ink is imprinted on the covered substrates in a bar code pattern.

The Patent Office

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Application No: GB 9808193.8
Claims searched: 1 to 34

Examiner: John Donaldson
Date of search: 13 May 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

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Int Cl (Ed.6): B07C 3/00, 3/10, 3/12; G06K 5/00, 7/00, 7/08, 9/00, 9/18, 9/20, 9/26, 9/60, 9/78, 17/00

Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	WO 94/20932 A1 (AUTHENTICATION TECHNOLOGIES), see abstract	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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